Comparison of Spoken Sentence Pairs by
Aphasic and Non-Brain-Damaged Subjects

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This study is one of a series of studies that we have carried out in order to determine how aphasic subjects go about comprehending single-sentence spoken messages. In these studies (Brookshire and Nicholas, 1980a; Brookshire and Nicholas, 1980b), we made use of a sentence verification procedure, in which a spoken sentence was presented to subjects along with a picture which either did or did not represent the meaning of the spoken sentence. Subjects were asked to judge whether or not the picture accurately represented the sentence meaning, and to report the results of their judgements by pushing buttons labeled "yes" or "no." Subjects' reaction times and error rates were then tabulated.

One of the most striking results of these previous studies suggested that when aphasic and non-brain-damaged subjects are presented with active transitive action sentences such as "The woman is washing the clothes," along with pictures which either match or do not match the meaning of the sentence, they carry out what has been called a "find and compare" strategy (Carpenter and Just, 1975). Subjects using a "find and compare" strategy carry out a series of serial comparisons between incoming sentence elements and their pictorial representations. As soon as a mismatch between a sentence element and its pictured referent is detected, the subject responds "false." If the entire sentence is heard with no mismatch detected, the subject responds "true." Such a strategy generates a characteristic pattern of reaction times for subject-verb-object sentences, with mismatches on subjects generating faster reaction times than mismatches on verbs or objects, and mismatches on verbs generating faster reaction times than mismatches on objects. Procedures that allow subjects to carry out such find-and-compare strategies permit them to judge sentence truth or falsity on the basis of individual lexical elements, without comprehending the meaning of the sentence as a whole.

In our second study (Brookshire and Nicholas, 1980b), we staggered the presentation of sentences and pictures so that in one condition pictures and sentences occurred simultaneously (as in the first study). In another condition, pictures were presented before sentences, and in a third condition, sentences were presented before pictures. Our intent was to determine if either of these latter two conditions would force subjects away from a find-and-compare strategy. We found that presenting sentences before pictures forced subjects away from such a strategy and required that they process the meaning of the sentence as a whole. This was not the case for conditions in which pictures were presented before or simultaneous with sentences. The study to be reported here represents our most recent attempt at requiring subjects to process sentences at a sentential meaning level using a verification procedure. In this study, pairs of spoken sentences were presented to subjects and they were asked to report whether or not sentences in each pair had equivalent meanings.

METHOD

Subjects. Ten non-brain-damaged and ten aphasic subjects participated in the experiment. Aphasic subjects were selected from the treatment roster of the Speech Pathology Section, Minneapolis Veterans Administration Medical Center. Five aphasic subjects exhibited "fluent" aphasia, and five exhibited "disfluent" aphasia. Table 1 presents Porch Index of Communicative Ability (Porch, 1967) percentiles for aphasic subjects. The ten non-brain-damaged subjects were selected from the Medical Center's Voluntary Service. Aphasic and non-brain-damaged groups resembled each other on parameters not related to neurological status.

Table 1. PICA percentiles for aphasic subjects in this study.

Disfluent Subjects	Overall	Gestural	Verbal	Graphic
D1	73	66	70	77
D2	50	95	26	67
D3	--	--	--	--
D4	87	95	75	87
D5	76	69	56	85
Fluent Subjects				
F1	73	76	72	73
F2	81	60	89	87
F3	55	58	53	56
F4	75	82	71	73
F5	46	66	49	17

Procedure. Spoken sentence pairs were presented to subjects within each of three conditions, and subjects were instructed to report, by pressing push buttons labeled "yes" and "no," whether or not the sentences in each pair had equivalent meanings. Forty-five sentences were presented in each condition. The 45 sentences presented in each condition were apportioned among a number of match and mismatch combinations (Table 2).

As can be seen in Table 2, those sentence pairs in which sentences within the pair had equivalent meanings could be comprised of identical active sentences, identical passive sentences, or pairs containing active and passive sentences with equivalent meanings. Sentence pairs which contained sentences which were not equivalent in meaning could involve mismatches on subject, verb, or object (in active sentence pairs), or could contain sentence pairs in which the agent and object of the first sentence were reversed in the second sentence. In the latter case, the reversals of agent and object generated grammatical, but anomalous sentences.

Table 2. Examples of sentence pairs used in this study.

Match	
Active-Active :	The man is painting the door. The man is painting the door.
Passive-Passive:	The pen is being held by the woman. The pen is being held by the woman.
Active-Passive:	The boy is chewing the gum. The gum is being chewed by the boy.
Passive-Active:	The bicycle is being sold by the girl. The girl is selling the bicycle.
Mismatch	
Subject (Active)	The man is carrying the suitcase. The boy is carrying the suitcase.
Vert (Active)	The girl is opening the window. The girl is closing the window.
Object (Active)	The boy is eating the apple. The boy is eating the orange.
Active-Reversed Active	The woman is painting the wall. The wall is painting the woman.
Passive-Reversed Passive	The doll is being washed by the girl. The girl is being washed by the doll.

The 45 sentence pairs described in Table 2 were randomly arranged and presented from a tape recording at comfortable listening level in three conditions (Table 3). In No Pause Condition, there was a one-second silent interval between the first and the second sentence in a pair, and a five second silent interval between each pair of sentences. In Unfilled Pause Condition, there was a ten-second silent interval between the first and second sentence in each pair, and a five second silent interval between each pair of sentences. In Filled Pause Condition, there was a ten-second interval between the first and second sentence in each pair and a five second silent interval between each pair of sentences. During the ten second interval between the sentences within pairs in Filled Pause Condition, the speaker who tape-recorded the sentences, said puh-puh-puh--at approximately 1/sec. Subjects were instructed and trained to say "puh-puh-puh" in unison with the speaker on the tape until the second sentence in the pair began.

Table 3. Summary of conditions used in this experiment.

<u>No Pause</u>

Sentence---1 second---sentence---5 seconds---next pair

<u>Unfilled Pause</u>

Sentence---10 seconds---sentence---5 seconds---next pair

<u>Filled Pause</u>

Sentence---10 seconds (puh-puh-puh)---sentence---5 seconds---next pair

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<u>Hypotheses</u>. We made a number of predictions about subjects' performance in this experiment. These predictions were based on a model of sentence comprehension which suggests that comprehension involves a two-stage process. The first stage, is a finite capacity, quick access, fast decay primary storage stage. In this stage, the sentence is stored verbatim; information regarding the syntactic structure and exact lexical content of the sentence is retained and available. However, information regarding the general meaning of the sentence may not be readily available at this stage. Information about a sentences' general meaning probably requires that the sentence be transferred to secondary memory. Secondary memory has large (and probably infinite) capacity, slow decay, and somewhat slower access. Moreover, when a sentence is transferred to secondary memory, information about the exact syntactic and lexical content of the sentence is generally lost, and the message is stored in terms of its semantic content.

We made the following predictions regarding subjects' performance on the active sentences presented in this experiment. First, No Pause Condition should allow, or even encourage, subjects to retain the first sentence in a pair in primary memory and to make serial comparisons between the contents of working memory and the incoming second sentence. Consequently, we would expect that there should be a strong tendency for subjects to engage in serial find-and-compare strategies in No Pause Condition. Reaction times to mismatches on subject should be faster than reaction times to mismatches on verbs, which should in turn be faster than reaction times to mismatches on objects. Second, Unfilled Pause Condition may permit fluent aphasic and non-brain-damaged subjects (who can subvocally rehearse the first sentence in a pair while waiting for the second sentence) to maintain the first sentence in primary memory by rehearsing it. These subjects could then carry out serial find-and-compare when the second sentence arrives. Disfluent aphasic subjects, if they are unable to rehearse the first sentence while waiting for the second, should be less likely to use a find-and-compare strategy in Unfilled Pause Condition. Therefore, their reaction times to sentences should not differ for mismatches on subject, verb, or object. Third, Filled Pause Condition should preclude subvocal rehearsal by all subjects. Therefore, all subjects should show obliteration of reaction time differences to mismatches on subject, verb, and object. Fourth, active-to-passive sentence comparisons should not be affected by the presence of pauses, either filled or unfilled because, according to the model, one must use secondary memory in order to determine whether active and passive sentences have equivalent meanings. In fact, we might speculate that filled pauses may even speed reaction times to active-passive and passive-active comparisons, by forcing subjects to store the first sentence of a pair in secondary memory, rather than retaining its verbatim form in primary memory.

We expected that aphasic subjects would do less well on active-passive and passive-active matches than on lexical mismatches. If aphasic subjects depend on find-and-compare strategies in sentence verification tasks, then active-passive and passive-active sentence pairs should pose particular problems for them, because in these sentence pairs sentence structure mismatches, but sentence meaning is equivalent. We also expected, based on the literature, that fluent aphasic subjects should respond more slowly and commit more errors to all sentence pairs than disfluent aphasic subjects would.

RESULTS AND DISCUSSION

The results are summarized in Figure 1. Figure 1 suggests that reaction times to subject mismatches were faster than reaction times to verb mismatches, which in turn were faster than reaction time to object mismatches in all conditions. There was a tendency for aphasic subjects' reaction times to verb mismatches to be proportionally longer, compared to their reaction times to subject and object mismatches, than comparable reaction times of nonaphasic subjects. We have seen this tendency in previous sentence verification studies, and it may suggest that verbs are somewhat more difficult for aphasic subjects than either subjects or objects. We had previously thought that aphasic subjects' difficulties with verbs might have been related to the fact that subject and object always appeared in the pictures that we had presented along with sentences, while verbs usually were not directly represented in pictures. Since no pictures were presented in the experiment reported here, the effects of verbs on aphasic subjects' reaction time do not seem to be explainable by their nonpicturability.

We have predicted that Unfilled Pause Condition would eliminate differences in reaction times to subject, verb, and object mismatches for disfluent aphasic subjects. This was not the case. Reaction times for both groups of aphasic subjects increased from No Pause to Unfilled Pause Conditions, but differences in reaction times to mismatches on subject, verb, and object were preserved. We can conclude, then, that (a) both groups of aphasic subjects depended upon rehearsal, or (b) neither did, and pause insertion had its effect for some other reason.

Contrary to our predictions, Filled Pause Condition did not obliterate differences in reaction times to mismatches on subject, verb, and object for any group of subjects. Non-brain-damaged subjects were relatively unaffected by Filled Pause Condition, while mismatch detection by aphasic subjects seems to have been facilitated by Filled Pause Condition. These findings suggest that subvocal rehearsal may play a minor role in sentence comparison tasks such as the ones used in this study, or that our distractor task was not demanding enough to interfere with subvocal rehearsal. It even may be that the "distractor" task served to maintain the alertness and attention of our aphasic subjects rather than interfering with their performance in this task.

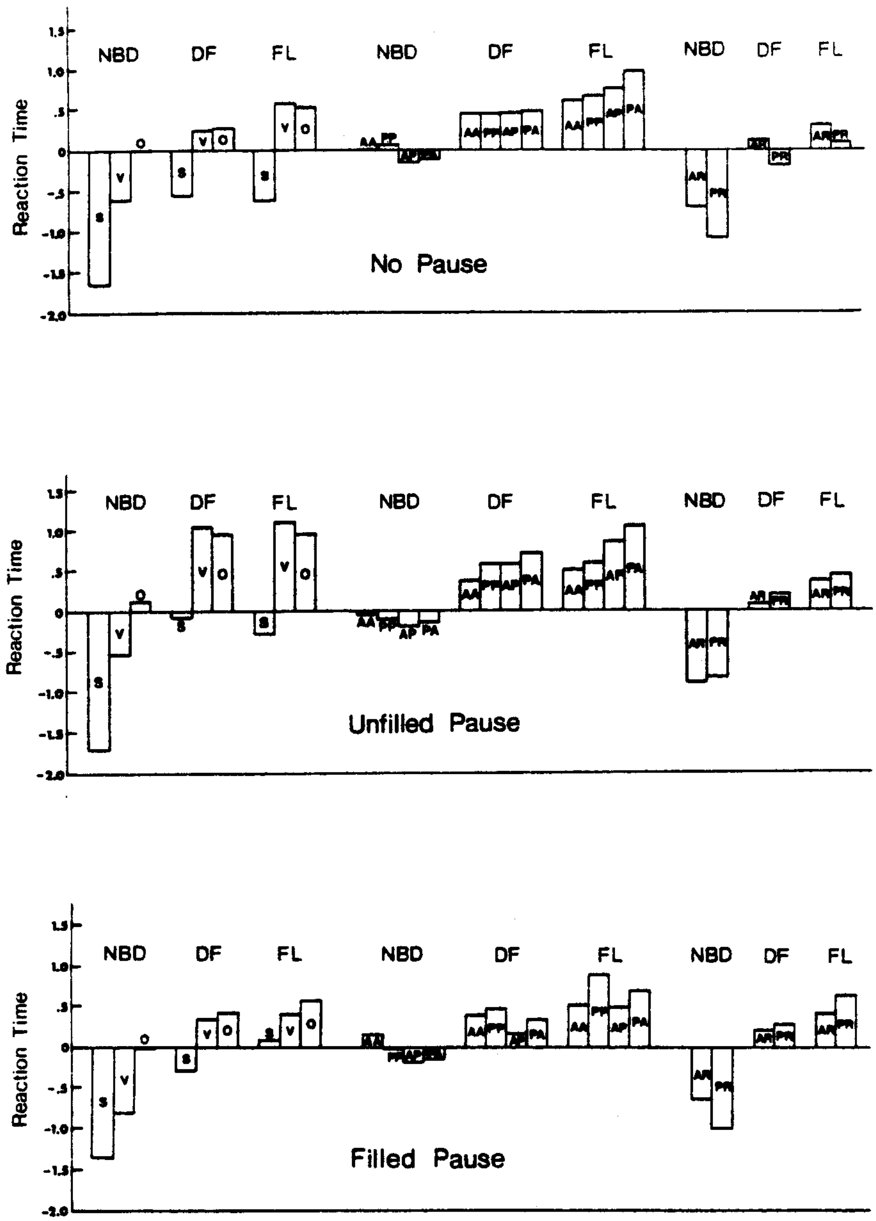

Figure 1. Reaction times of non-brain-damaged (NBD), disfluent aphasic (DF), and fluent aphasic (FL) subjects to sentences delivered in No Pause, Unfilled Pause, and Filled Pause Conditions.

Unfilled pauses had little effect on reaction times to active-to-passive and passive-to-active comparisons. Filled pauses, however, speeded up reaction times to these comparisons, at least for aphasic subjects. This result was consistent with our hypothesis, and suggests that filled pauses may have enticed aphasic patients to transfer the initial sentence of sentence pairs to secondary memory instead of attempting to retain it in primary memory while waiting for the second sentence.

Aphasic subjects did surprisingly well on active-to-passive and passive-to-active comparisons in all conditions. Only one of ten aphasic subjects performed at "chance" levels on these comparisons, although these sentence pairs did generate more errors for aphasic subjects than any other kind of sentence pair. Nevertheless, it appears that most aphasic subjects are generally successful at ignoring structural differences among sentences and identifying sentences which have equivalent meanings.

Overall, fluent aphasic subjects generally took slightly longer to respond to most sentences in most conditions than disfluent aphasic subjects did. Error rates for both groups of subjects were low (less than 5 percent errors per condition) and essentially equivalent.

In summary, then, we once again found a progression of increasing reaction times to mismatches on subjects, verbs, and objects of active sentences, in spite of procedures which were designed to discourage subjects from employing find-and-compare strategies in the sentence verification task. At this time we cannot be certain whether these results occurred because subjects were able to circumvent the intent of our procedures, or because the progression of increasing reaction times to subject, verb and object mismatches in active sentences is not necessarily the result of the find-and-compare strategy. The most pleasing (and somewhat surprising) aspect of the results of this study was the capability of aphasic subjects to judge whether or not sentences had equivalent meanings, even when syntax differed. These results suggest that aphasic persons generally retain the ability to deal with the meaning of sentences even in the face of disparate syntactic structures.

REFERENCES

Brookshire, R.H. and Nicholas, L.E. Verification of active and passive sentences by aphasic and nonaphasic subjects. J. Speech and Hearing Research, 23, 878-893, 1980.

Brookshire, R.H. and Nicholas, L.E. Sentence verification and language comprehension of aphasic persons. In R.H. Brookshire (Ed.), Clinical Aphasiology: Conference Proceedings, 1980. Minneapolis, MN: BRK Publishers, 53-63, 1980.

Carpenter, P.A. and Just, M.A. Sentence comprehension: A psycholinguistic processing model of verification. Psychological Review, 82, 45-73, 1975.

Porch, B.E. Porch Index of Communicative Ability. Palo Alto, CA: Consulting Psychologists Press, 1967.